

## POSTGLACIAL DISTRIBUTION PATTERNS OF MAMMALS IN THE SOUTHERN COASTAL REGIONS OF ALASKA\*

David R. Klein†

**D**URING the Wisconsin glaciation the present land areas of the coastal regions of Alaska bordering the Gulf of Alaska were virtually completely overridden by ice. The now existing flora and fauna of the region have presumably become established in the 10,000 years since the recession of the ice.

Swarth discussed the origins of the fauna of the "Sitkan District" in 1936, and since then additional knowledge of the glacial history of the southern coastal regions of Alaska has become available, permitting a new interpretation of the distribution patterns of mammals (Heusser 1960, Miller 1958, Flint 1957, and Karlstrom 1964). The present distribution of mammals in this region, although complicated by the phenomenon of insularity, reflects the sequence of their arrival and their relationship to specific refugia.

A brief review of the late-Wisconsin geology and postglacial vegetation of the southern coastal areas of Alaska will serve as a useful base for understanding the mammalian distribution patterns of the region. Heusser (1960) has shown that the ice, covering virtually all this region, receded about 10,000 years ago. The islands of the Alexander Archipelago were apparently free of ice at least a few hundred years before the adjacent mainland whereas in Prince William Sound, on the Kenai Peninsula, and on Kodiak Island glacial recession took place approximately 1,000-2,000 years later than in the Alexander Archipelago. In the intervening region of the mainland, from Mt. Fairweather to Cape Suckling, late-Wisconsin ice apparently did not cover much more land than is now occupied by glaciers although major postglacial tectonism has been a complicating factor in this area (Miller 1958).

As the ice melted, associated changes in sea-level took place. In the Alexander Archipelago it is probable that during the Wisconsin glacial maximum, sea-level was lower than at present, exposing greater expanses

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†Alaska Cooperative Wildlife Research Unit, College, Alaska.

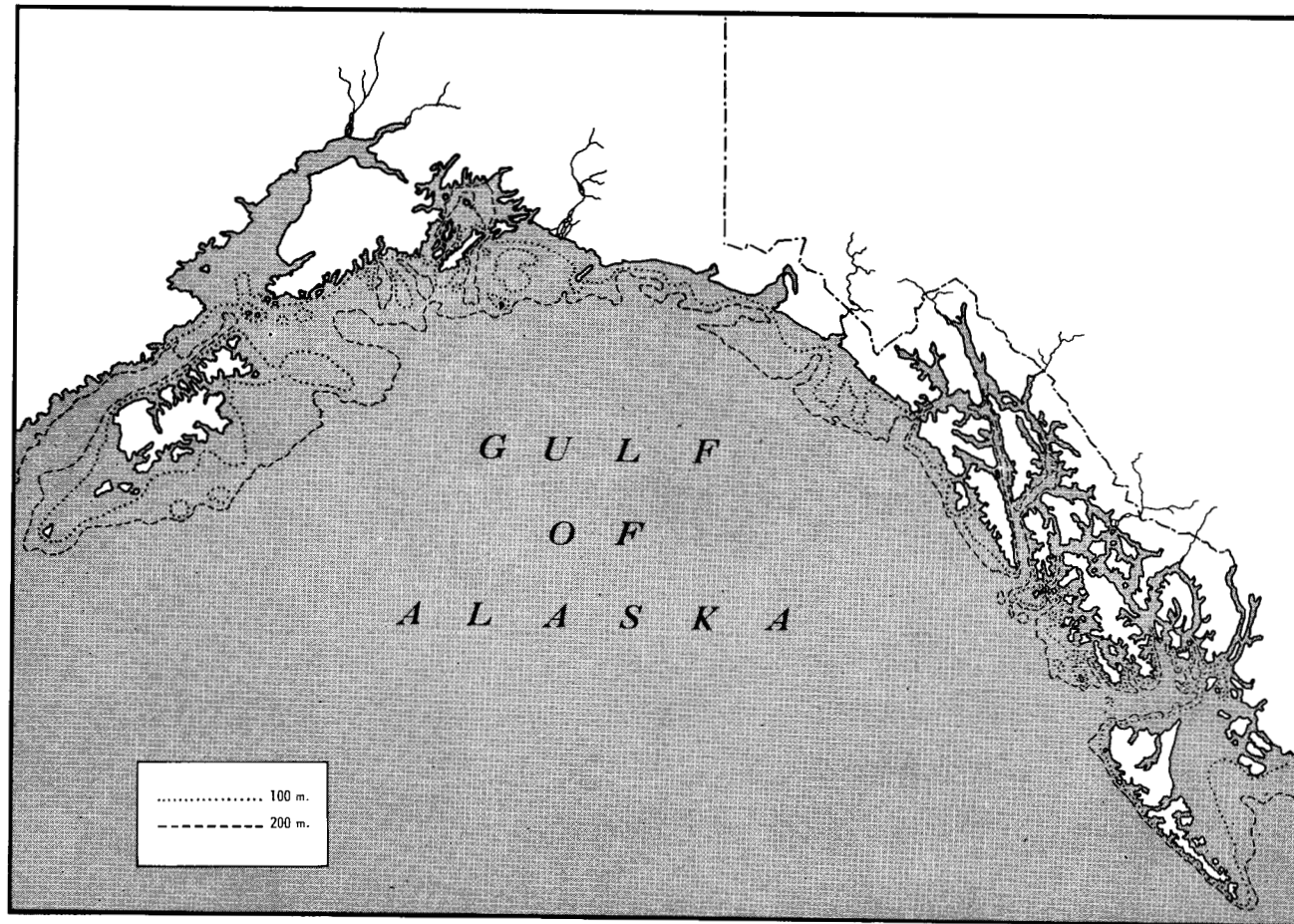


Fig. 1. The southern coastal region of Alaska showing the 100- and 200 metre depth contours.

of land, creating connections between islands and mainland, and narrower channels between islands. This situation probably continued for a short time after the ice had left this region before the great continental ice sheet with its large volume of stored water had decreased significantly in size (Flint 1957). Later, as the continental ice sheet melted, the sea-level rose considerably. The rise of sea-level was offset in some regions by crustal upwarping of the land following the removal of the load of ice from the land. In the Juneau, Lituya Bay, and Katalla areas beach terraces have been found 30-100 m. above present sea-level, but in the region of Prince William Sound sea-land relationships appear not to have greatly changed since the recession of ice (Heusser 1960).

Following ice recession, land areas rapidly became vegetated. Heusser's (1960) pollen investigations indicate that alder, ferns, sedges, and willows were dominant vegetation types immediately following the ice recession, constituting a floral complex perhaps similar to that of the present treeless areas of the Alaska Peninsula. In the Alexander Archipelago lodgepole pine (*Pinus contorta*) was the dominant early tree species. With the gradual development of soils the pine was replaced on the better sites by Sitka spruce (*Picea sitkensis*) and mountain hemlock (*Tsuga mertensiana*); more recently western hemlock (*T. heterophylla*) has become a dominant member of the forests of the region.

From the end of the Wisconsin glaciation to the present, access to the southern coastal region of Alaska by mammals has been restricted by the physical barrier of the Coast Range mountains with their extensive ice fields. Access from the interior regions has for many species only been possible via the larger river valleys that bisect the Coast Range mountains. However, access was not possible through all river valleys. The precipitous canyon of the Copper River has apparently served as an effective barrier in preventing moose from penetrating to the favourable habitat of the Copper River delta. Moose were not present in the Yakutat-Dry Bay area until 30-40 years ago, after the recession of the glaciers that obstructed the Alsek River valley near the Alaska-British Columbia boundary (Kindle 1952). Moose were apparently not present on the lower Stikine in Alaska when gold seekers traveled through the area in the mid-1870's during the Cassiar gold rush, but they had become established there shortly after the turn of the century (Swarth 1922). A legend of the Stikine Indians of the area tells that in the past the Stikine valley was obstructed by the coalescing of the Great and Choquette glaciers and that the river at the time flowed through a tunnel below the ice (Kerr 1948). Great Glacier at the present time terminates only a few hundred metres from the river.

There is some evidence that small, localized refugia existed in the Queen Charlotte Islands (McCabe and Cowan 1945; Foster 1963), in the region between Cape Spencer and Katalla (Miller 1958), on the Kenai Peninsula (Heusser 1960; Karlstrom 1964), and on Kodiak Island (Karlstrom 1957), but most of these were probably too small to support mammal populations or, as in the case of the Queen Charlotte Islands, may have been too isolated

to serve as a point from which the larger land mammals could move into surrounding areas. The smaller land mammals present a somewhat different picture. Consideration of the possible location and extent of small refugia in terms of the evidence of unglaciated areas in the southern coastal region is perhaps misleading, because the sea-level was much lower in late-Wisconsin times than at present and large areas that are now covered by the ocean would have been exposed or ice covered. Hultén (1937) considers the currently submerged continental shelf as a possible route of migration of plants from the region of Washington and Oregon and the Queen Charlotte Islands to southern coastal Alaska immediately after glaciation. Both Heusser (1960) and Hultén (1937) present botanical evidence suggesting the existence of a refugium in the Kenai Peninsula area. On the basis of geological evidence Karlstrom (1964) has reported on the existence of Pleistocene refugia on the western side of the Kenai Peninsula under climatic conditions not greatly different from those of today. These refugia could have been the source of some of the floral complex represented by pollen in the postglacial bog deposits sampled by Heusser near Seward. Heusser, however, suggested the existence of a "local" refugium largely on the basis of the early presence of Sitka spruce in the Seward deposits, and it is doubtful whether Sitka spruce could have survived under climatic conditions in the western Kenai Peninsula refugia. Geological evidence for refugia in the Prince William Sound area is lacking but there are extensive coastal shelves that would be exposed by a lowering of present sea-level by 100 metres. Fig. 1 is a map of the southern coastal region of Alaska showing the 100 and 200-metre depth contours which indicate that appreciable land areas would be exposed by a lowering of the present sea-level. The postulation of refugia in low areas now submerged seems more logical than the postulate that low-altitude forms of plants and small mammals survived on the few nunataks that may have existed on some of the islands. That these coastal shelf areas were unglaciated during the Wisconsin glacial maximum is subject to question. Glaciation in the lowlands of the Katalla-Yakutat-Dry Bay areas was apparently not much more extensive than at present (Miller 1958). However, Karlstrom (1964) feels that on the basis of geological evidence from the islands of Prince William Sound and from bottom samples from the coastal shelf it is probable that most areas in the adjacent Gulf of Alaska which would be exposed by a lowering of sea-level by 100 m. were glaciated during the Wisconsin glacial maximum. Johnston (1933) has suggested that the rising of land adjacent to the coast after ice started to recede probably preceded the rise of sea-level caused by melt water. If any refugia did exist in areas now submerged, species of plants and animals existing in them would have been able to follow the receding ice to the land now above sea-level and thus survive when the refugia became flooded.

### Small Mammals

The present distribution and affinities of small mammals in the Alaskan southern coastal area can be explained by either or both of the following

hypotheses:

1. Refugia existed in some offshore areas now submerged at least during the Wisconsin glaciation, as well as land connections between islands or between islands and the mainland.
2. The affinities of some species of small mammals occurring on widely separated islands are the result of parallel morphological changes occurring under similar environmental stimuli in postglacial times.

Some of the inter-island faunal relationships of the region are illustrated in the following discussion. Mammal taxonomy follows Rausch (1953) and Hall and Kelson (1959) and for the purposes of this paper Rausch is considered the final authority.

In the Alexander Archipelago endemic forms occur most frequently on the outer islands, including Chichagof, Baranof, Coronation, Warren, and Forrester islands whereas the islands lying closer to the mainland more often are occupied by mainland forms. This is shown by the distribution of members of the genus *Peromyscus* of which *P. maniculatus* is restricted to the mainland and most of the adjacent islands, including the larger islands of the Queen Charlotte group, whereas the larger form, *P. sitkensis*, occurs on Baranof, Chichagof, Coronation, Warren, Duke, and Forrester islands and in the Queen Charlotte group only on Kunghit, Frederick, Hippa, and a few other small islands. Foster (1963) has recently suggested that *P. maniculatus* and *P. sitkensis* are conspecific because a cline exists between them, their morphological differences are not great, and they probably interbreed.

The genus *Microtus* also has a characteristic distribution pattern in the Alexander Archipelago. *M. longicaudus* is present on most islands and the adjacent mainland. An endemic species, *M. coronarius*, closely related to *M. longicaudus*, is found only on Coronation, Warren, and Forrester islands whereas on Baranof and Chichagof islands *M. oeconomus* is present, which occurs also on the nearest parts of the mainland in the vicinity of Glacier Bay.

Among the insectivores, *Sorex obscurus longicauda* is the mainland form occurring also on a few of the nearest islands in the southern part of the region. *S. o. elassodon* is present on most other islands of the Alexander Archipelago including Baranof and Forrester islands and the larger Queen Charlotte Islands, but *S. o. malitiosus* is found only on Coronation and Warren islands and *S. o. prevostensis* is restricted to Kunghit Island in the Queen Charlotte group.

The faunal affinities between several of the outer islands of the Alexander Archipelago and the Queen Charlotte group, particularly Baranof and Chichagof-Coronation and Warren-Forrester-Kunghit (and other small islands on the western side of the Queen Charlotte Islands), suggest that these areas had closer land connections during some past period. A lowering by 100 m. of the sea-level associated with the Wisconsin period would not bring about a continuous land connection between these island groups although the land masses would be larger and the intervening channels would be fewer and narrower. It is possible, however, that during a slightly

earlier period, before Cross Sound, Chatham Strait, Summer Strait, and Dixon Entrance were deepened by glacial action, landbridges between these areas could have been exposed after a lowering of the sea-level. Cowan (1935) feels that the distribution of the *Peromyscus sitkensis* group and of *Sorex obscurus ellassodon* suggests that these forms survived the Wisconsin glaciation on the outer islands in this region. On the basis of his studies in the Queen Charlotte Islands, Foster (1963) suggests that the evidence is strong for the existence of Wisconsin refugia there but feels that *P. sitkensis* and possibly *S. obscurus ellassodon* did not survive the Wisconsin glaciation. He postulates inter-island dispersal of the *P. sitkensis* forms via Indian canoe in Recent times.

Although mammals confined to west-coast refugia would apparently be in an advantageous position to occupy land areas exposed by the receding ice, their poor success in this respect in contrast to forms originating from the mainland could be explained by the wide water barriers separating the westernmost islands from those adjacent to the mainland and the apparently poorer adaptability of the insular forms. It is generally recognized that insular species frequently become highly specialized and therefore less adaptable than mainland forms (Mayr 1942). Cowan (1935) pointed out this suggested relationship for *Peromyscus sitkensis*, which he felt to be a less "vigorous" species than *P. maniculatus*. Additionally, if the two "species" interbreed as Foster (1963) suggests the much larger gene pool of the mainland form would enable it to absorb the insular populations to which it had access.

In the Prince William Sound region Hinchinbrook and Hawkins islands show the closest affinities to the adjacent mainland, whereas Montague Island has endemic mammalian forms suggesting longer isolation and possibly closer relationship to the Kenai Peninsula than to adjacent Hinchinbrook and Hawkins Islands. Hinchinbrook Entrance has apparently been a fairly effective barrier to mammalian movement during postglacial times.

**Table 1.** List of fossil mammals from North American Pleistocene refugia that have been present in Recent times in the southern coastal region of Alaska.

Interior Alaska-Bering Sea refugium <sup>1</sup>		Refugium south of continental ice sheet <sup>2</sup>
Carnivora		
Wolf	<i>Canis</i> sp.	<i>Canis lupus</i>
Black Bear		<i>Ursus americanus</i> ( <i>Euarctos americanus</i> )
Brown Bear	<i>Ursus</i> sp.	
Artiodactyla		
Deer		<i>Odocoileus hemionus</i>
Moose	<i>Alces</i> sp.	<i>Alces alces americanus</i> ( <i>A. americanus</i> )
Elk	<i>Cervus canadensis</i> <sup>3</sup>	<i>Cervus canadensis</i>
Caribou	<i>Rangifer</i> sp.	<i>Rangifer</i> sp.
Mountain sheep	<i>Ovis dalli</i>	<i>Ovis canadensis</i> ( <i>O. montana</i> )
Mountain goat		<i>Oreamnos</i> sp.

1. Péwé, T. L. 1957. Permafrost and its effect on life in the North. 18th Biol. Colloquium Corvallis, Oregon. pp. 12-25.
2. Osborn, H. F. 1921. The age of mammals. New York: Macmillan Company. 635 pp.
3. Murie, O. J. 1951. The elk of North America. Harrisburg, Penn: Stackpole Co. 376 pp.

*Clethrionomys rutilus* has reached both Hawkins and Hinchinbrook islands from the adjacent mainland but has failed to reach Montague Island. The same situation apparently also holds for the spruce grouse, *Canachites canadensis*. Montague Island has two endemic subspecies of rodents, *Microtus oeconomus elymocetes* and *Marmota marmota sheldoni*. The marmot of the mainland, *M. m. caligata* is also present on Hawkins and Hinchinbrook islands. While some of the Montague Island fauna exhibit subspecific differences from those of adjacent land masses, these differences apparently have been the result of isolation from related stocks during postglacial times.

The mammalian complex of Kodiak Island, although sparse, shows closest affinities with that of the Alaska Peninsula. Mammals present are very similar to mainland forms and do not suggest long isolation.

### Large mammals

All Recent large land mammals of the southern coastal region of Alaska apparently are postglacial arrivals coming from refugia either in the interior Alaska-Bering Sea region or from south of the continental ice sheet. Species that were present in these two refugia during Pleistocene times and later occupied the southern coastal region of Alaska are shown in Table 1. It should be understood that these lists are based on the findings of fossil remains, and the indicated absence of an animal in one of the refugia is no proof that it did not occur there. However, the fairly extensive fossil remains unearthed in both areas probably indicate the distribution of these species during the Wisconsin period. Fig. 2 shows the present distribution of large mammals in the southern coastal region of Alaska.

### Brown bear, *Ursus arctos*

Remains of the *Ursus arctos* type have been found only in the Alaskan Pleistocene material and are not known from regions south of the continental ice sheet. Present distribution of the brown bear in Alaska suggests origin from a northern refugium (Swarth 1936). The presence of the brown bear on all large islands northwest of Frederick Sound including Kodiak Island and the islands of Prince William Sound suggests that this bear had access to these areas in a very early postglacial period, possibly before the sea-level had risen substantially and prior to the arrival of the black bear and most ungulates. The present lack of movement of brown bears across the water channels separating these islands also supports the thesis that these bears reached the islands when access was easier than at present. Possibly access to the northern islands of the Alexander Archipelago was via the coastal route from the Prince William Sound region. The type of habitat existing immediately after ice recession would certainly have been favourable for brown bears. Salmon, which are an important component of the summer diet, are known to become established in streams within a few years after access to the sea is possible, and the sedges, berry-bearing shrubs, and other vegetation first occupying land following ice recession are



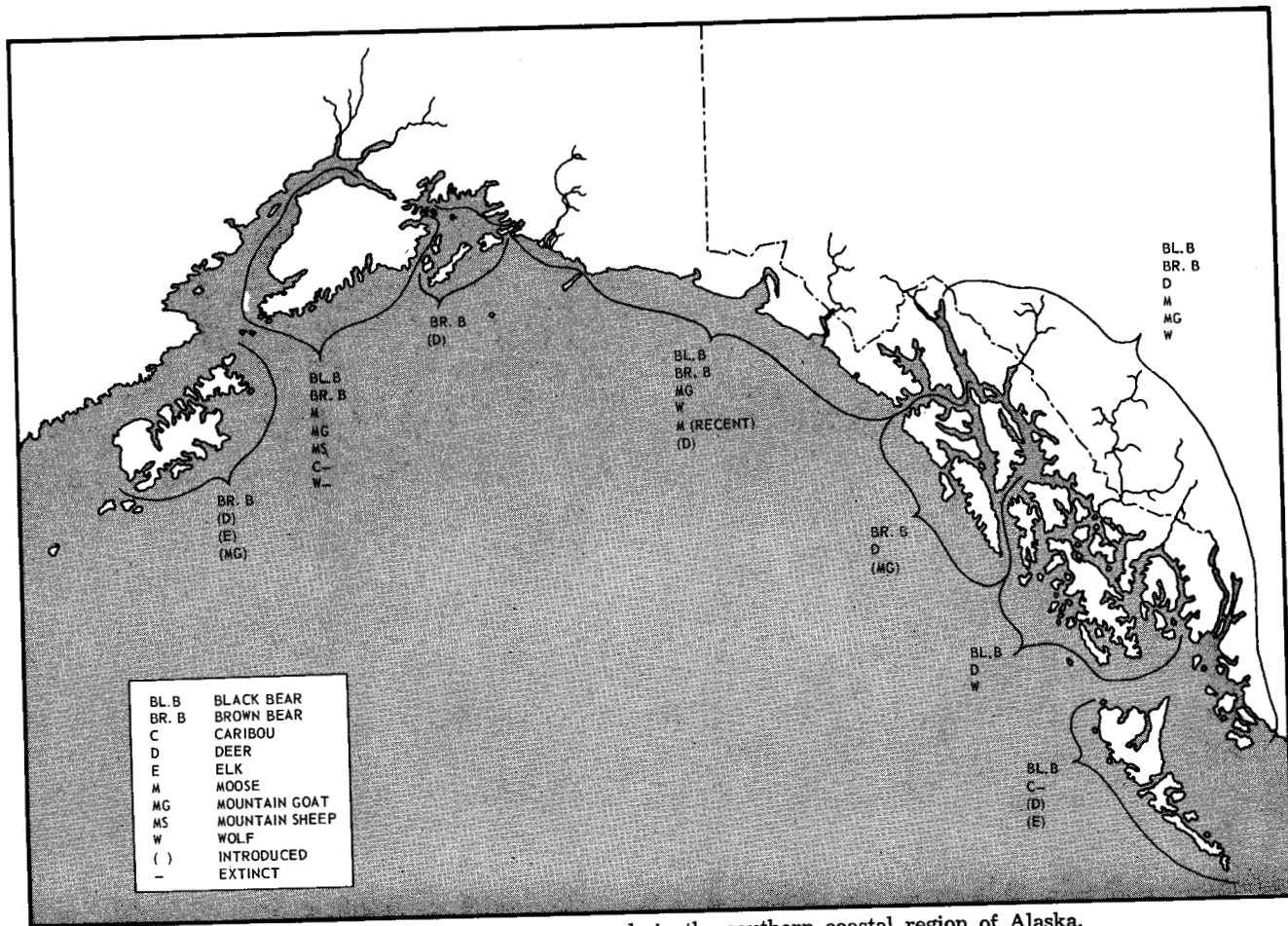


Fig. 2. Distribution of large mammals in the southern coastal region of Alaska.



the preferred vegetable food of these bears. In this respect habitat would be favourable much earlier for bears than for most ungulates.

The failure of the brown bear to occupy islands south of Frederick Sound when access became available may be a result of prior occupancy by the black bear. A previously established species obviously has an advantage over a similar form attempting to occupy the same ecological niche. In recent times brown bears occasionally reach Mitkof and Wrangell islands but have not been able to establish populations. Additionally, movement of brown bears south along the mainland from Lynn Canal to Cape Fanshaw may have been obstructed during early postglacial times by extensive areas of slowly receding glaciers, many of which even now reach the sea, and later by the general rise in sea-level that restricted movement of land mammals.

#### **Black bear, *Ursus americanus***

The black bear is apparently a migrant from the south. There is no evidence that it was present in the northern refugium. Although the black bear is widely distributed on the Alaska mainland it is absent from the coastal islands northwest of Frederick Sound, suggesting that it arrived in the adjacent mainland areas later than the brown bear and consequently was not successful in penetrating to these islands as was the brown bear. It is perhaps pertinent here to note that the black bear is today associated with forested areas, whereas the brown bear appears more adaptable, being found in the treeless tundra, as well as in the coastal rainforests. The black bear is not present on the Alaska Peninsula or the treeless coastal areas adjacent to the Bering Sea and Arctic Ocean.

South of Frederick Sound the black bear has occupied all the larger islands of the Alexander Archipelago and is also found on the Queen Charlotte Islands. Again it appears to have reached these areas from the south prior to the arrival of the brown bear from the northwest. Its presence on the Queen Charlotte Islands indicates a fairly early arrival, according to Osgood (1901), as these islands are now separated from the mainland by the 35-mile-wide Hecate Strait. McCabe and Cowan (1945) suggest that the black bear may have survived the last glaciation together with several other mammals in a refugium on these islands. The Queen Charlotte Island black bear, recognized as a distinct species for many years, is now afforded sub-specific status (*U. a. charlottae* Osgood). Access to the islands of the Alexander Archipelago south of Frederick Sound poses no serious problems for moderate swimmers, as water channels between islands and the mainland are frequently less than a mile wide.

#### **Wolf, *Canis lupus***

In the southern coastal region of Alaska the distribution pattern of the wolf is almost identical with that of the black bear, but this apparently is not a result of similar zoogeographical history. A dissimilarity is the absence of the wolf from the Queen Charlotte Islands. The distribution of the wolf, an obligate predator, obviously depends on the prior establishment of a

suitable prey species. In the taiga and arctic regions of North America the main prey of the wolf appear to be members of the Cervidae. Although mountain sheep, mountain goats, bison, and musk ox fall prey to wolves, these species do not appear to offer a sufficient basis to maintain the wolf as a species in any given area. Murie's (1944) studies of wolves in Mount McKinley National Park, where both mountain sheep and caribou are available, tend to support this assumption.

The wolf probably followed the deer into coastal southeastern Alaska and penetrated to those deer-occupied islands to which they were capable of swimming. Their absence from Admiralty, Baranof, and Chichagof islands and the Queen Charlotte Islands (although in recent times the only native cervid on the Queen Charlotte Islands, the caribou, may have existed at too low a density to support the wolf) suggests that the wolf arrived in this region at a fairly late date, when conditions were probably not too different from those at present. The absence of the wolf from the islands of Prince William Sound and Kodiak Island is understandable because ungulates are not native to these islands. In the mainland region from Prince William Sound to Cape Spencer, where the mountain goat is the only native ungulate, with the exception of the recently arriving moose in the Yakutat-Dry Bay area, wolves are present only sporadically, apparently because individuals occasionally penetrate the Coast Range mountains.

#### **Black-tailed deer, *Odocoileus hemionus sitkensis***

The black-tailed deer came obviously from the south, the species being present during Pleistocene time only in the southern refugium. Its successful establishment in the Alexander Archipelago depended on a suitable habitat with a vegetation probably not unlike the present one. This would preclude its dispersal from a refugium until a suitable habitat had developed not only in the Alexander Archipelago but in the intervening areas as well. This factor, combined with the deer's apparently following the highly dissected coast and offshore islands, undoubtedly slowed its northwestward movement. In addition, conditions on the mainland, where deep winter snows are common, are not nearly so favourable for deer as on the adjacent islands, and the establishment of deer along the coast would be delayed in those areas where the islands are separated from one another by wide water channels. The absence of deer, except through recent introduction by man, on the Queen Charlotte Islands attests to the effectiveness of Hecate Strait as a barrier to these quite strong swimmers. Deer have occupied all islands of the Alexander Archipelago capable of supporting them (with the exception of Forrester Island) and occur on the mainland northwest of Juneau in the Eagle River area. Their access to a favourable habitat in Prince William Sound and on Kodiak Island has been blocked by the exposed coastal area north of Cross Sound where conditions are not suitable for their survival. In recent years deer have been successfully introduced by man to islands in Yakutat Bay, the islands and adjacent mainland of Prince William Sound, and to Kodiak Island. It is interesting to note that deer have been

able to reach Admiralty, Baranof, and Chichagof Islands which are isolated by fairly wide water channels, whereas their predator, the wolf, has not been able to penetrate to these islands.

### **Moose, *Alces alces***

The moose, although apparently present on the Kenai Peninsula since earliest recorded times (Lutz 1960), has only recently penetrated the Coast Range mountains at the Alsek (Yakutat-Dry Bay area), Chilkat, Taku, Stikine, and Unuk River valleys. Extensive occupation of the southern coastal regions of Alaska by moose cannot be expected, because suitable habitats are restricted to a few sizable areas where the vegetation is still in the early stages of succession and which occur only in the larger river valleys of the mainland and on the terminal moraines of glaciers that have receded recently. Moose have been successfully introduced in the past 15 years to the Copper River delta and Berners Bay.

Moose existed in the Pleistocene fauna of both the northern and southern refugia and present distribution seems to indicate that the form *A. alces gigas* derived from the northern refugium whereas the other three North American races were of southern origin. *A. a. gigas* is present wherever the moose occurs in the Alaskan coastal area from the Alaska Peninsula southeast to the Taku River although intergradation with *A. a. andersoni* probably takes place in the vicinity of the Taku River. Moose in the Stikine and Unuk River valleys are more typically of the smaller *andersoni* type, which occurs in adjacent British Columbia. It should be noted that this line of demarcation between races of moose roughly corresponds to that between the brown and black bear on the islands and in both cases results from the meeting of forms apparently derived from different refugia.

### **Caribou, *Rangifer tarandus***

Caribou have not penetrated into the southern coastal region of Alaska except on the Alaska Peninsula and the Kenai Peninsula and on both have been restricted almost exclusively to the dryer western sides. In the remainder of the region suitable caribou habitat does not exist. The small numbers of caribou present on Graham Island of the Queen Charlotte group until about 1920 (Cowan and Guiguet 1956), apparently were a relict from a period when the vegetation was more favourable for the species. Changing habitat, possibly accelerated by fires started by man, may have caused the extinction of the caribou on the Kenai Peninsula before 1900.

### **Elk, *Cervus canadensis roosevelti***

The Recent species of North American elk or wapiti has been reported from both the southern and northern refugia. It apparently became extinct in Alaska sometime during the late Pleistocene and has failed to return to Alaska in post-glacial times. The Rocky Mountain elk (*C. c. nelson*) has been introduced by man to the Queen Charlotte Islands and the Roosevelt

elk (*C. c. roosevelti*) to Afognak Island in the Kodiak group. The elk possibly would be successful in other coastal areas, although the Queen Charlotte elk have apparently remained in a very restricted area on Graham Island with a stabilized population of a few hundred animals (Foster 1961). The failure of the elk to reach Alaska in Recent times is apparently caused by the extensive intervening areas of unfavourable habitat. The Roosevelt elk, the race best adapted to the wet coastal forest regions, occurs naturally as far north as Vancouver Island and formerly was found on the mainland as far north as the Fraser River delta. In many respects its winter diet of broadleaf species closely resembles that of the moose, therefore the absence of the elk from the coniferous rain forests of the coast north of the Fraser River is understandable.

#### **Mountain goat, *Oreamnos americanus kennedyi***

The mountain goat is known only from the southern refugium and has apparently extended its range since the Pleistocene northwestward through the Coast Range mountains of the mainland to the Kenai Peninsula and the Talkeetna Mountains. Because the mountain goat lives in the alpine zone during the summer and the coniferous forest during the winter, the coastal mountains have been a help to spreading rather than a barrier as they are to many other mammals. On the other hand, the goat's preference for a mountainous habitat has contributed to its failure to cross to the larger islands adjacent to the coast, where it would undoubtedly find support. While not as proficient swimmers as deer, goats are capable of crossing the narrow channels separating many of the offshore islands from the mainland. Thus, goats have reached Culross and Bainbridge islands in Prince William Sound (Klein 1953); one goat was observed on Wrangell Island for several years and they apparently occur on Pitt Island just south of Prince Rupert (McCabe and Cowan 1945). All these islands are separated by narrow straits from the mainland, which rises precipitously from the sea. The successful establishment of goats on any of the islands would require more than just the occasional crossing by a single goat. Goats have been introduced by man to Baranof, Chichagof, and Kodiak islands.

The present northern and western limits of mountain goat distribution may be a product of a relatively late arrival from a rather distant refugium. There are indications that the mountain goat is extending its range northward and there have been occasional reports in recent years from the eastern portion of Mt. McKinley National Park in the Alaska Range (Klein 1953; Murie 1962). The low broad Susitna River valley has probably been a barrier to the movement of goats west from the Chugach and Talkeetna Mountains and may account for their absence from the west side of Cook Inlet.

Precipitous forested slopes broken by rock outcrops appear to be an important component of mountain goat winter range in areas where heavy snows are common. Such areas shed the snow to a large extent and offer cover and access to food. This factor may be of importance in determining the long term success of mountain goats on Kodiak Island where they have

been introduced or in future range extensions either by natural or artificial means.

### Mountain sheep, *Ovis dalli*

Mountain sheep were part of the Pleistocene fauna of both the northern and southern refugia; the thinhorn sheep (*O. dalli*) was the form of the Alaskan refugium, and the bighorn sheep (*O. canadensis*) that of the southern refugium. *O. dalli* is the species occurring now in Alaska and south to northern British Columbia, and the bighorn sheep occupies the Rocky Mountains north to central British Columbia and Alberta. Mountain sheep, being primarily grazers throughout the entire year, require a relatively dry habitat where grasses and other alpine vegetation are available to them in both winter and summer. Consequently, these sheep have not been able to penetrate into the areas of heavy precipitation on the coastal side of the Coast Range mountains. This is borne out by mountain sheep living on the dry interior slope of these mountains and therefore having access to the coastal areas. The mountain sheep does occur on the Kenai Peninsula but here it is restricted to the dry western slopes of the Kenai Mountains.

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